Loudspeakers

Chapter

Loudspeakers

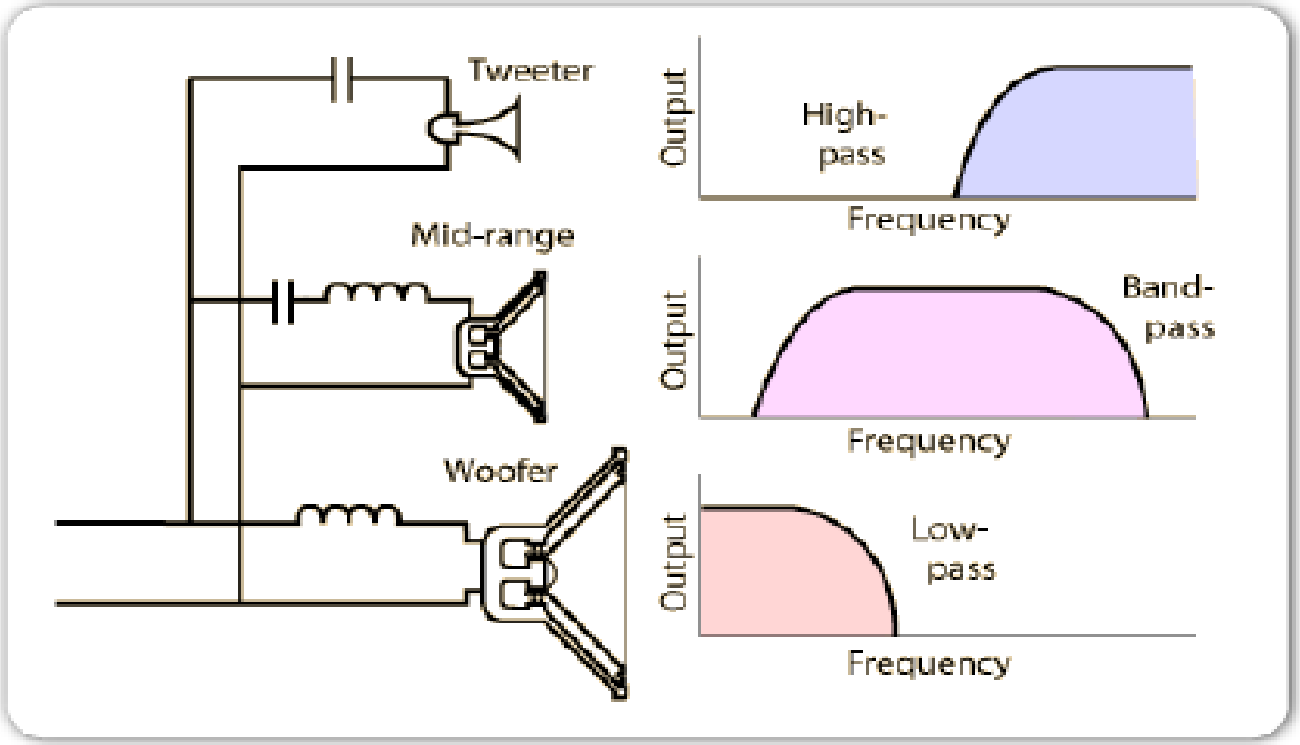
- A loudspeaker is a device containing one or more electroacoustic transducers which converts electrical energy (or an electric signal) into acoustical energy (or an acoustical signal). This is usually achieved by a diaphragm which vibrates to produce sound waves when excited by the electrical signal.
- The term Loudspeaker can refer to individual transducers known as Drivers or to complete systems consisting of enclosure incorporating one or more drivers and electrical filter components.

- To produce a wide range of frequencies, most loudspeaker systems require more than one driver particularly for high sound pressure level or high accuracy.

- The drivers are named **subwoofers** (very low frequencies), **woofers** (low frequencies), mid-range speakers (middle frequencies), **tweeters** (high frequecies) and sometimes super tweeters optimized for the highest audible frequencies.

- When **multiple drivers** are used in a system, a " **filter network**" called a **Crossover** separates the incoming signal into different frequency ranges, and routes them to the appropriate driver.

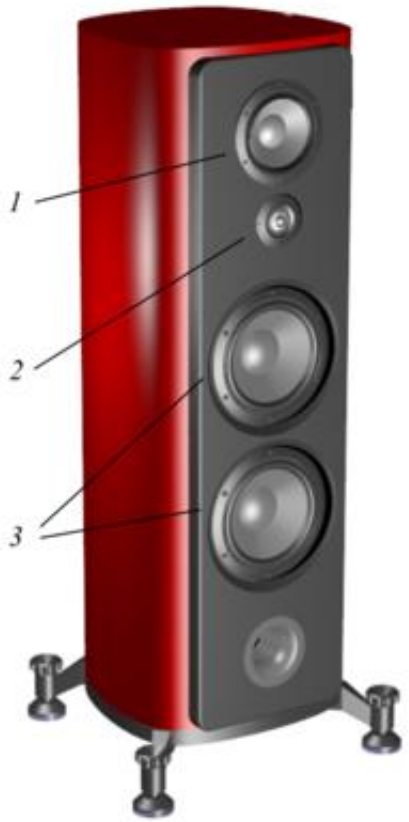
Crossover Network



- A loudspeaker system with n separate frequency bands is described as “n-way speakers”, for example a 2-way system will have woofer and tweeter speakers; a 3-way system is either a combination of woofer , mid-range and tweeter.

The types of loudspeakers:

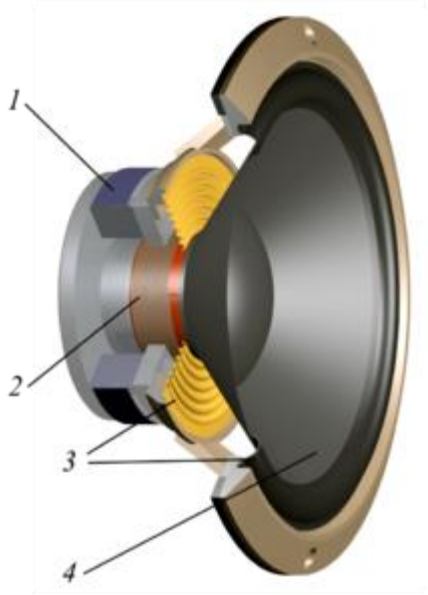
- Moving-coil loudspeakers
- Electrostatic loudspeakers
- Ribbon loudspeakers
- Horn loudspeakers
- Piezoelectric loudspeakers



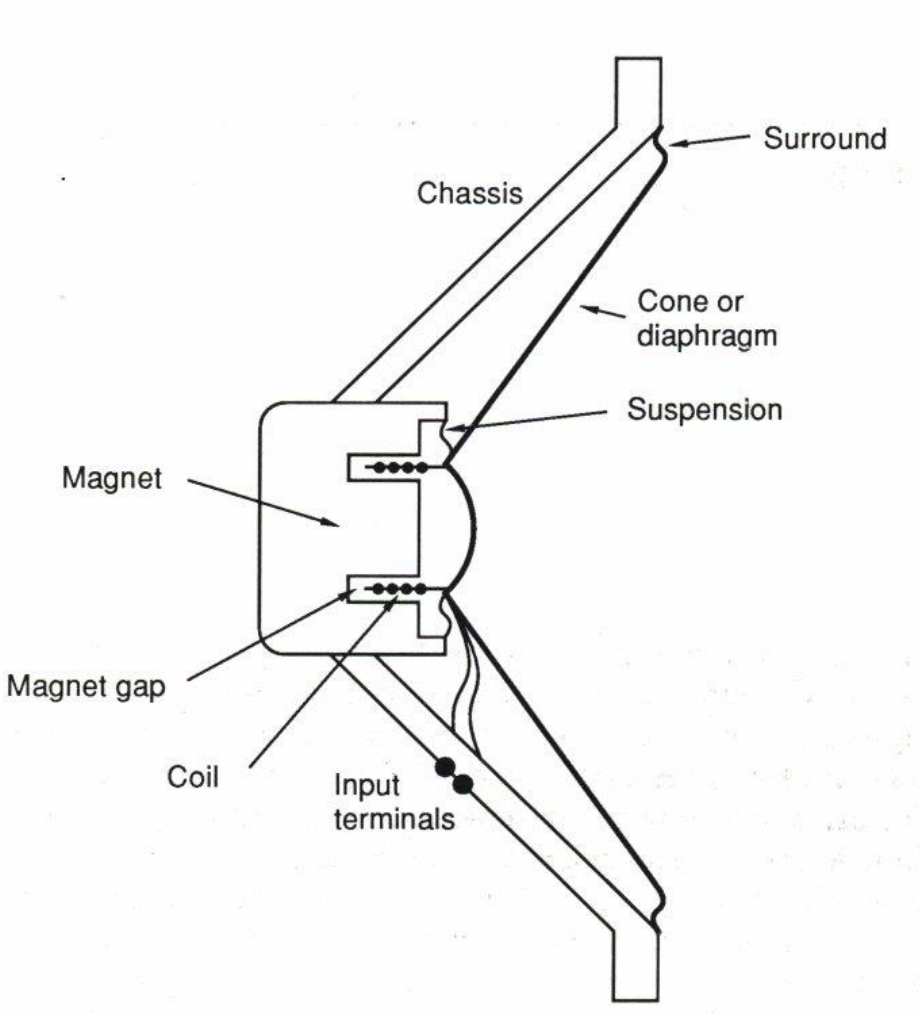
Loudspeaker for home use with three types of dynamic drivers

1. Mid-range driver
2. Tweeter
3. Woofers

Moving-coil loudspeakers



1. Magnet
2. Voicecoil
3. Suspension
4. Diaphragm



Principle of moving-coil loudspeakers

- The moving-coil loudspeaker consists of diaphragm (or cone), coil, magnet, chassis. The device is also called “driver”, as it forms the core unit of speaker that drives air to produce sound.
- The coil which seats in the magnet gap is wounded around a cylindrical former which is attached to the diaphragm (or cone).
- The diaphragm is usually manufactured with a cone- or dome-shaped profile. A variety of different materials may be used, but the most common are paper, plastic, and metal.

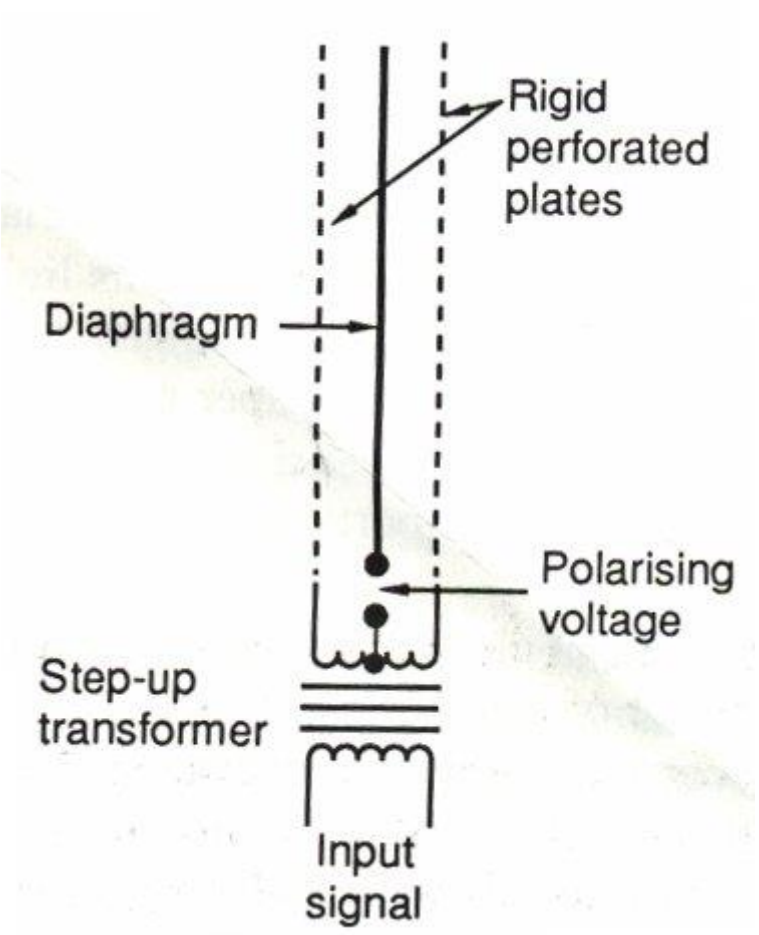
- The ideal material should be:
  - Rigid, to prevent uncontrolled cone motions;
  - Have low mass, to minimize starting force requirements and energy storage issues;
  - Be well damped, to reduce vibrations continuing after the signal has stopped with little or no audible ringing due to its resonance frequency as determined by its usage.
- The diaphragm is held in its rest position by a suspension system which consists of a compliant cloth material and a complaint surround around the edge of the cone made by e.g. rubber. This allows the required amount of movement of the cones..

- The suspension system keeps the coil centered in the gap and provides a restoring (centering) force that returns the cone to a neutral position after moving.
- A typical suspension system consists of two parts: the *spider*, which connects the diaphragm or voice coil to the frame and provides the majority of the restoring force, and the *surround*, which helps center the coil/cone assembly and allows free pistonic motion aligned with the magnetic gap.

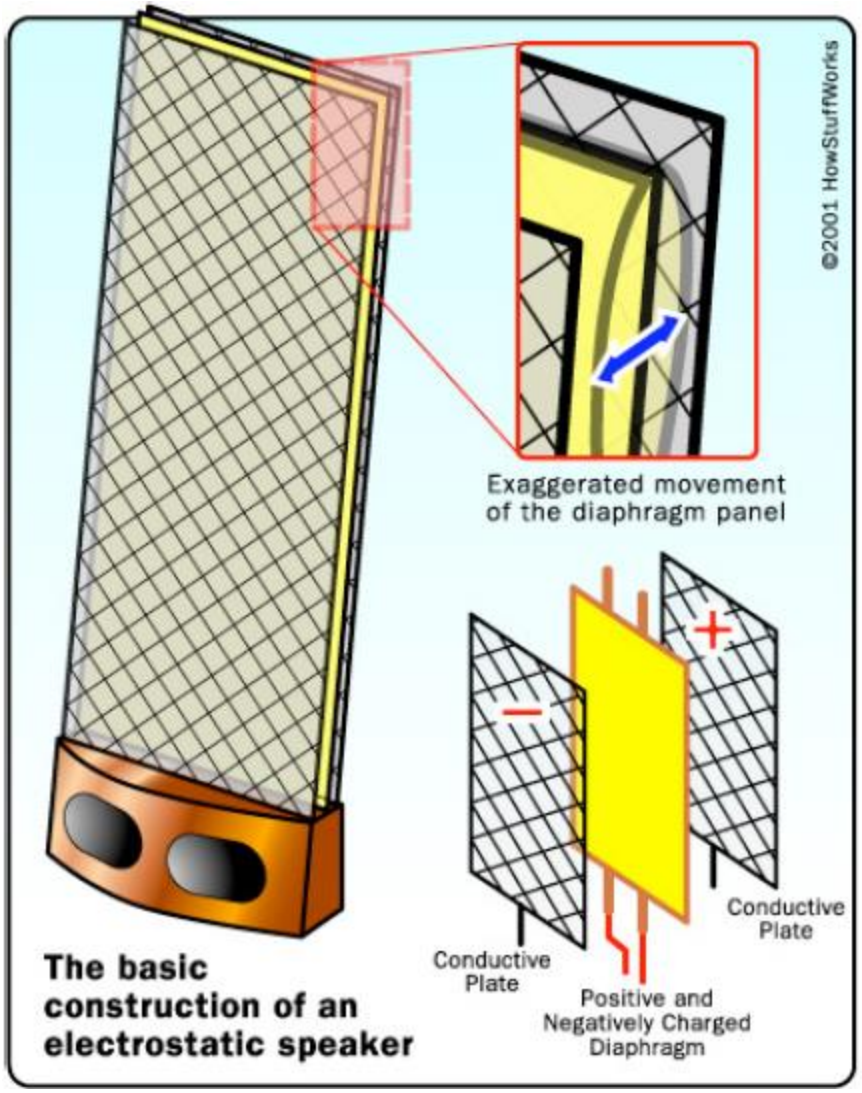
- The chassis , frame, or basket, is designed to be rigid, as this will reduce the potential distortions due to rough handling of the speaker.
- Chassis are typically cast from aluminum alloy, or stamped from thin steel sheet, though in some drivers with large magnets cast chassis are preferable
- The moving-coil loudspeaker is based on the principle of electromagnetic transduction.
- It is the exact reverse of the process involved in the moving-coil microphone

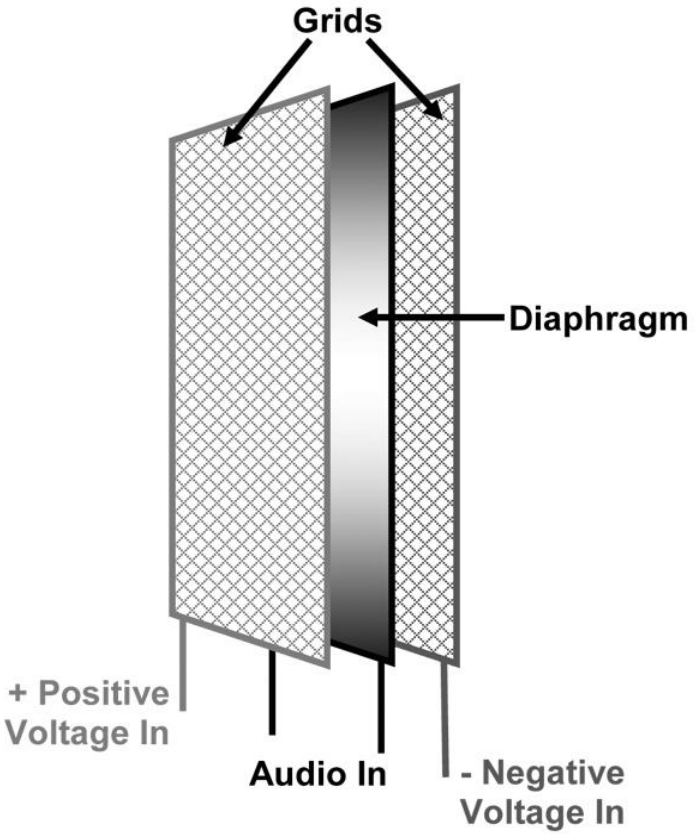
Electrostatic loudspeaker

- The drive unit of the electrostatic loudspeaker consists of a large flat diaphragm (side view shown in the figure) of light weight, placed between two rigid plates.
- The diaphragm has a very high resistance. The polarising voltage charges the capacitor formed by the narrow gap between diaphragm and the plates.
- The input signal modulates (through the transformer) the electrostatic field between the two rigid plates. The change of the input signal alters the force on the diaphragm, thus causing the vibration of the diaphragm to produce sounds.



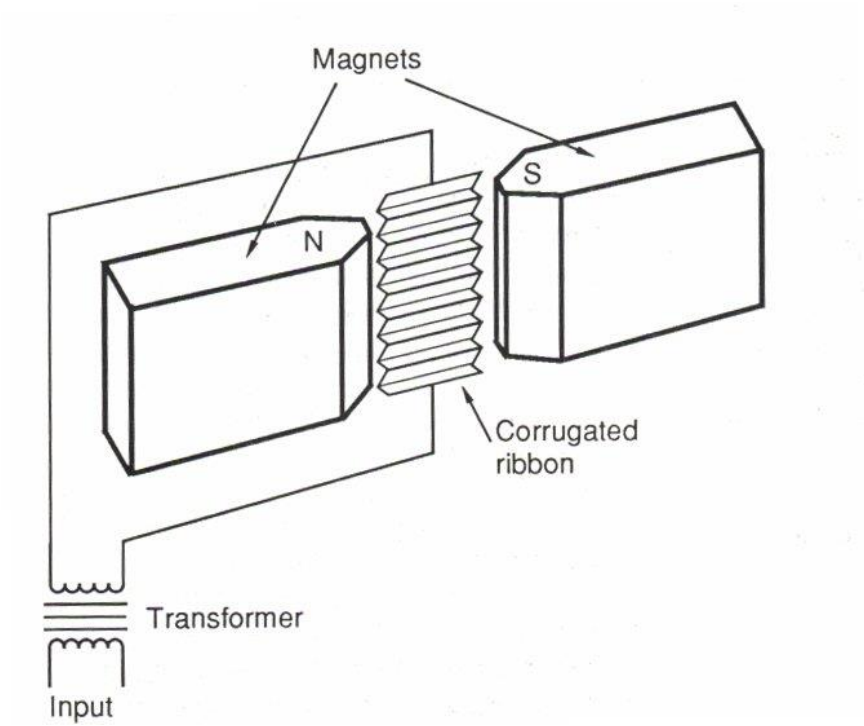
Electrostatic loudspeaker





Ribbon loudspeaker

- A light corrugated aluminium ribbon, clamped at each end, is placed between two magnetic poles.
- The input signal is applied (via transformer) to each end of the ribbon. The alternating nature of the signal causes an alternating magnetic field, and thus the ribbon to vibrate which produces sounds.
- The advantage of a ribbon driver is that the ribbon has very little mass; thus, it can accelerate very quickly, yielding very good high-frequency response.
- A horn is usually placed in front of the ribbon to give a higher output for a given electrical input.



Horn loudspeaker

- A horn is an acoustic transformer which helps to improve acoustic efficiency by matching the air impedance at the throat of the horn with that at the mouth.
- For a given electrical input, it can increase the acoustical output of a driver by 10 dB or more compared with that driver mounted in a conventional cabinet.
- A very large horn is needed to reproduce low frequencies, and relatively small horns for high frequencies, and larger ones for upper mid frequencies. As such, it is frequently employed at mid and high frequencies as a large size is sometimes limited in practice.

Horn
Throat

Driver

Horn
Mouth

Piezoelectric loudspeakers

- Piezoelectric speakers have a total different working principle than an electro dynamic speaker.
- There is no coil, no magnetic field and no large current consumption.
- The heart of each piezoelectric speaker is a ceramic disc that interacts when it feels a certain voltage difference.
- An increase of the signal amplitude Vpp (Voltage peak to peak), will result in a larger piezo deformation and result in a larger sound output.
- More Vpp creates more sound output Piezoelectric speakers can be seen as a capacitive load with values between 10nF and 1µF.

Piezoelectric loudspeakers

- Piezoelectric speakers are frequently used as beepers in watches and other electronic devices, and are sometimes used as tweeters in less-expensive speaker systems, such as computer speakers and portable radios.
- Piezoelectric speakers have several advantages over conventional loudspeakers: they are resistant to overloads that would normally destroy most high frequency drivers, and they can be used without a crossover due to their electrical properties.
- There are also disadvantages: some amplifiers can oscillate when driving capacitive loads like most piezoelectrics, which results in distortion or damage to the amplifier.

Piezoelectric loudspeakers